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APPARATUS FOR BLENDING OF ADDITIVES INTO FLUID STREAMS

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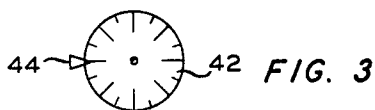
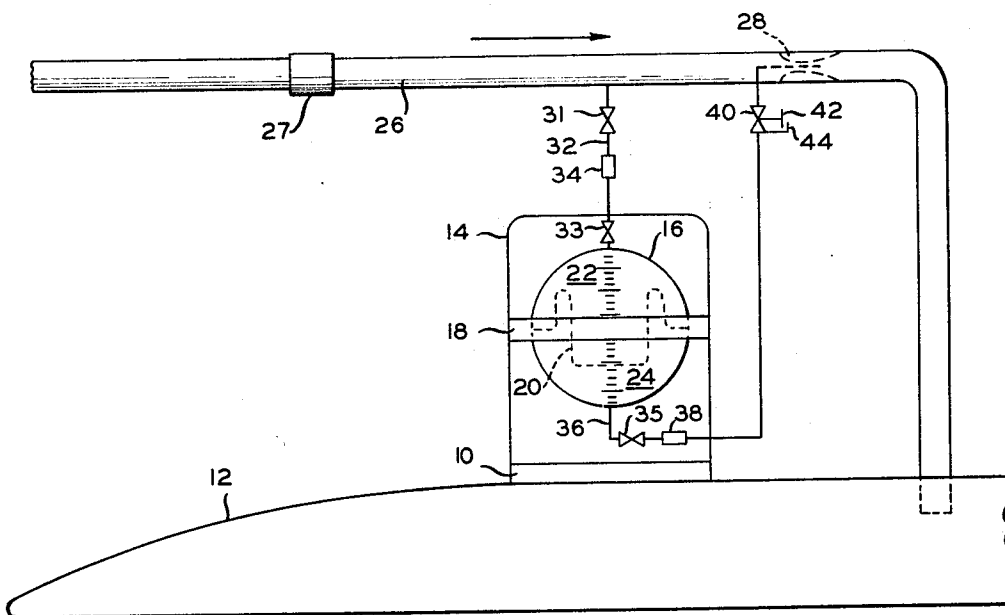
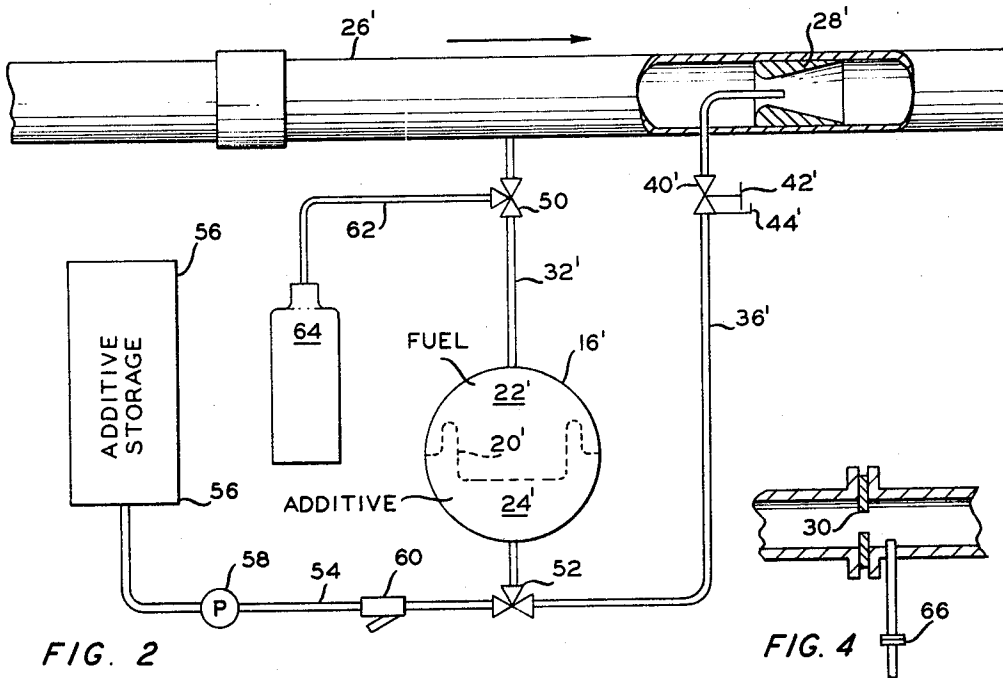


FIG. 1

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ATTORNEYS

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APPARATUS FOR BLENDING OF ADDITIVES INTO FLUID STREAMS

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ABSTRACT OF THE DISCLOSURE

In an apparatus for accurately proportioning small quantities of additive into a stream flowing in a main conduit having a constriction therein, the pressure upstream of said constriction is applied against a diaphragm in a two-compartment container to force additive from one compartment of said container into said main conduit downstream from said constriction. Dry-break couplers and three-way valves are provided in conduits connecting said container to said main conduit. Means are also provided for measuring the amount of additive needed to refill said container.

This invention relates to the blending of additives into fluid streams. In one aspect this invention relates to the blending of additives into liquid hydrocarbon fuels.

For years the aircraft industry has combatted the problem of ice formation in aircraft fuel systems by the use of power consuming fuel heating devices. More recently, however, efficient anti-icing additives have been developed which eliminate the necessity for employing said fuel heating devices. In U.S. Patent 2,952,121, issued to B. Mitacek on Sept. 13, 1960, there is disclosed and claimed a method of preventing the plugging of filters and other points of restricted flow due to ice formation in the fuel system of a jet aircraft which comprises utilizing a fuel containing a small amount of certain glycol ethers such as the monomethyl ether of ethylene glycol or the monomethyl ether of diethylene glycol. Such additives have been found to give excellent results in preventing the formation of ice crystals in fuel systems.

In U.S. Patent 3,032,971, issued May 8, 1962 to J. A. Shotton, there is disclosed and claimed an improved combination anti-icing additive which comprises a blend of a polyhydroxy alcohol, e.g., glycerol, and a glycol ether, e.g., the monomethyl ether of ethylene glycol. When said alcohols and said glycol ethers are used in combination, there is obtained an additive which is a much better additive than either said polyhydroxy alcohol or said glycol ether alone. The combination additives of Shotton are superior to the Mitacek additives and provide improvements in the operations of jet engines in at least two respects: (1) said combination additives not only act as an anti-icing agent and prevent plugging of the fuel system at points of restricted flow such as filters, valves, orifices, etc., due to ice formation, but also (2) eliminate or reduce deteriorating action on the fuel tank coatings. Additives in accordance with the invention of said Shotton patent have met with outstanding success. They have been adopted by the U.S. Air Force and military specifications now require that they be used in all JP-4 jet fuels supplied to the U.S. Air Force. Said additives in accordance with the invention of said Shotton patent have also been approved by the Federal Aviation Agency for use in commercial aircraft.

The above-described fuel additives of said Mitacek and said Shotton patents possess an additional very important property which is independent of said anti-icing properties. This is the property of rendering biocidal the fuel and fuel systems wherein said additives are utilized. In the past, consumers of liquid hydrocarbon fuel products have encountered operational difficulties associated with

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said fuels and the fuel systems wherein said fuels are utilized. In the case of burner and diesel fuels, these difficulties have taken the form of fuel filter plugging, dirty injector nozzles, etc. In the past few years many of these difficulties have been definitely associated with microbiological activity in the fuel storage supplying the fuel utilization systems. Another facet of microbiological activity is corrosion damage to the fuel storage tanks. These difficulties associated with microbiological activity have been particularly serious in the aircraft industry utilizing jet fuels, but have been encountered with all distillate fuels ranging from gasolines through kerosenes and including the various grades of jet fuels. Difficulties of this nature have focused attention on said problems because of the critical nature of the failure of an aircraft fuel system, particularly while in flight.

The above-described fuel additives can be utilized in fuels in very small amounts ranging from 0.001 to 3.0, preferably from 0.01 to 1.0, more preferably from 0.01 to 0.5, and still more preferably from 0.05 to 0.2, volume percent of the fuel. When it is desired to utilize both the anti-icing and biocidal qualities of said additives, it is desirable to use at least 0.05 volume percent of the additive. Depending upon the temperatures involved, the anti-icing qualities can frequently be obtained to a sufficient extent when using amounts less than 0.05 volume percent. As an example of a situation where it is desired to utilize both qualities of the additive, Air Force specifications require the use of from 0.1 to 0.15 volume percent of an additive in accordance with the invention of said Shotton patent.

The use of such small amounts of additives has created unusual problems in uniformly blending said small amounts into the fuel. This is particularly true when the total amount of fuel to be blended is small. For example, when fueling a small aircraft requiring only a small amount of fuel, e.g., 100 to 200 gallons, or when fueling a truck, tractor, etc., requiring only 15 to 50 gallons. The properties of said additives, together with the small amounts thereof used, are such as to prevent their proper utilization by simply dumping the additive into the fuel tank. It is important that the additive be blended into the fuel gradually so that it is uniformly distributed throughout the fuel. Methods and apparatus have been devised which will properly blend the additive into large quantities of fuel which are to be used relatively quickly and in large quantities, e.g., as by the Air Force at military bases. However, even though the problems of anti-icing protection and protection against microbiological activity are the same for small aircraft as for large aircraft, facilities for supplying the additive to the fuel for small aircraft users are inadequate, particularly at the smaller air terminals. The same is true with respect to fuels used in vehicles other than aircraft, which can also benefit from the use of a fuel containing one of said additives.

The present invention provides a solution to the above difficulties by providing an improved apparatus and method for blending a small amount of an additive into a relatively small quantity of fuel. In one embodiment the invention provides a portable device which can be carried on board the aircraft, or a land vehicle, and employed together with a portable storage container for the additive to place the additive in the fuel, regardless of where the vehicle is refueled. In another embodiment the invention provides apparatus of a fixed nature which can be employed in combination with existing fueling equipment at fueling stations without requiring extensive modification of said existing equipment.

An object of this invention is to provide an improved apparatus for blending an additive into a fluid stream. Another object of this invention is to provide an improved apparatus particularly adapted for blending small quanti-

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ties of an additive into small quantities of fuel, particularly hydrocarbon fuels. Another object is to provide an improved method and apparatus which can be employed for uniformly blending an additive into a fluid, such as a liquid fuel. Still another object of this invention is to provide an improved apparatus which can be employed along with existing equipment, e.g., pumping equipment, already available at air terminals or other fueling locations, without extensive modification of said existing equipment. Other aspects, objects and advantages of the invention will be apparent to those skilled in the art in view of this disclosure.

Thus, according to the invention, there is provided an apparatus for quantitatively supplying an additive to a fluid stream, said apparatus comprising, in combination: a main flow conduit adapted to be connected at one end to a source of fluid supply; a constriction disposed in said main flow conduit; a container; a flexible impermeable diaphragm dividing said container into a first compartment and a second compartment; first conduit means connected at one end to said main flow conduit upstream from said constriction and at the other end to said first compartment of said container; second conduit means connected at one end to said second compartment of said container, the other end extending into said main flow conduit downstream from said constriction; and a flow control means disposed in said second conduit means.

FIGURE 1 is a diagrammatic illustration of one form of apparatus in accordance with the invention.

FIGURE 2 is a diagrammatic illustration of another form of apparatus in accordance with the invention.

FIGURE 3 is a plan view illustrating a detail of one element of the apparatus of FIGURE 1 and FIGURE 2.

FIGURE 4 is a view, partly in cross section, illustrating a modification of the apparatus of FIGURES 1 and 2.

Referring now to the drawings, wherein like reference numerals are employed to denote like elements, the invention will be more fully explained. In FIGURE 1, an apparatus in accordance with the invention comprising a portable platform 10 is shown resting on the wing 12 of an aircraft. A carrying handle means 14 extends upwardly from said platform. An additive container 16 is removably secured to said platform and said handle means by means of band 18 which surrounds said container and is secured to said handle means. A thin flexible impervious membrane or diaphragm 20 is secured to the inner walls of said container and divides same into a first upper compartment 22 and a second lower compartment 24. Said additive container 16 is preferably formed from a transparent or translucent material in order that the position of said diaphragm 20 can be observed through the walls of the container and employed as a measure of the container contents by means of the graduated scale shown along the outside of the container. Glass can be employed for fabricating said container but nonbreakable plastics such as polyethylene or polypropylene are preferred. As shown in the drawing, said container can preferably be substantially spherical in shape. However, it is within the scope of the invention to employ containers of any other suitable shape, e.g., elliptical cylindrical, etc.

A main flow fueling conduit 26 is connected at its upstream end to a source of fuel supply (not shown) and the downstream end of said conduit extends into an opening in the wing tank of the aircraft. Although not shown in the drawing, it will be understood that the downstream end of said fueling conduit can terminate in a conventional dispensing nozzle. A constriction 28 is disposed in said main flow conduit. Said constriction 28 can be any suitable type of a constriction adapted to cause a region of increased pressure upstream therefrom and a region of decreased pressure downstream therefrom. Preferably, said constriction is a venturi eductor. However, said con-

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striction can also be in the form of a plate 30 having an orifice therein as shown in FIGURE 4.

A first conduit means 32 is connected at one end to said main flow conduit in communication with the region of increased pressure upstream from said constriction 28. The other end of said first conduit means is connected to said container 16 and in communication with said first compartment 22. A first dry-break coupling means 34 is disposed in said first conduit means between said main flow conduit and said container. Said dry-break coupling means can be any suitable dry-break coupler known to the art. As will be understood by those skilled in the art, a number of these devices are available on the market. Generally speaking, such devices comprise in the art, a number of these devices are available on a valve means in each end of the two portions of the conduit which are coupled together, and said valves are each actuated when the coupler is coupled together and close when the coupler is uncoupled.

A second conduit means 36 is connected at one end to said container and in communication with said second compartment 24. The other end of said second conduit means extends into said main flow conduit 26 to a point within the region of decreased pressure downstream from said constriction 28. A second dry-break coupler 38 is disposed in said second conduit means adjacent said container 16. Instead of employing said dry-break couplers 34 and 38, conventional valves 31 and 33 can be disposed in said first conduit means 32 and conventional valve 35 disposed in said second conduit means 36. In such instance, said dry-break couplers can be any suitable type of coupling means, preferably a fast-break coupler. However, said dry-break couplers are definitely preferred for obvious reasons of convenience.

A calibrated valve 40 is disposed in said second conduit means between said dry-break coupler 38 and said main flow conduit 26. Said calibrated valve can be any suitable type of valve provided with means for determining the extent to which the valve is opened. One type of such valve can comprise a needle valve having a calibrated dial 42 mounted on the valve stem and provided with an index pointer 44 attached to the valve body and oriented to index with calibrations on said dial 42. Any other suitable type of flow control means can be employed instead of said valve 40. For example, said flow control means can be an orifice of predetermined fixed size as shown in FIGURE 4.

Although shown in the drawings as being supported or removably secured to said platform 10, said container 16 can be employed without said platform 10.

Referring now to FIGURE 2, there is illustrated another embodiment of the invention which is similar in principle and operation to that illustrated in FIGURE 1. The apparatus of FIGURE 1 is primarily a portable apparatus whereas the apparatus of FIGURE 2 is intended primarily as a fixed apparatus. In FIGURE 2 a first three-port valve 50 is connected, by means of two of the ports therein, into first conduit means 32' which extends between main flow conduits 26' and upper first compartment 22' of container 16'. A second three-port valve 52 is connected, by means of two of the ports therein, into second conduit means 36'.

A third conduit means 54 is connected at one end to an additive storage tank 56 and at the other end into a third port of said second three-port valve 52. A pump 58 is disposed in said third conduit means adjacent said tank 56. Preferably, although not essential, a valve is disposed in conduit means 54 upstream of said pump 58. Said pump 58 can be any suitable type of a small pump, and preferably is a small hand-operated pump. A strainer 60 can be disposed in said third conduit means between said pump 58 and said second three-port valve 52, if desired.

A drain or discharge conduit 62 is connected at one end into the third port of said first three-port valve 50

and the other end extends to a suitable drain or container 64. Said container can be any suitable type of container, preferably one which is graduated and can be employed to measure the contents of first compartment 22', as described hereinafter.

A flow control means preferably comprising a calibrated needle valve 40', as described in connection with FIGURE 1 above, is disposed in said second flow conduit means 36'. Similarly, as in the apparatus of FIGURE 1, said flow control means can be an orifice 66 of predetermined fixed size as indicated in FIGURE 4.

The portions of said first conduit means, said second conduit means, and said third conduit means, other than the valve, coupling, etc. and the other elements therein can be fabricated from any suitable tubular conduit materials. Flexible tubing made of suitable plastics, e.g., polyethylene, are presently preferred.

As used herein and in the claims, unless otherwise specified, the word "downstream" when employed in describing the region of decreased pressure downstream from a constriction in a conduit includes the region of decreased pressure in the throat of a venturi eductor such as 28 or 28'.

In the practice of the invention when employing the above-described apparatus of FIGURES 1 and 2, it is first necessary to know the amount of fuel which is to be loaded aboard an aircraft or other vehicle. Knowing this, one can then select a container 16 of the proper size, e.g., from one pint to one gallon, or larger. Commonly, a one-half gallon container is employed.

Referring again to FIGURE 1, in the operation of the apparatus as there assembled employing dry-break couplers 34 and 38, and assuming that compartment 24 of container 16 has been filled with additive and compartment 22 is essentially empty, pumping of fuel is started through main flow conduit 26. Fuel flowing through venturi 28 causes a region of increased pressure on the upstream side thereof and a region of decreased pressure on the downstream side thereof. The amount of said changes in pressure will depend upon the fuel flow rate primarily and to some extent upon the characteristics of the particular venturi or other constriction employed in flow conduit 26. Immediately after flow of fuel has been started, calibrated valve 40 is opened to a predetermined setting, depending upon the desired concentration of additive in the fuel. Said valve will have been previously calibrated for various fuel flow rates, various desired additive concentrations, and the particular constriction being employed in conduit 26. Upon opening of said valve 40, fuel will flow from said region of increased pressure in flow conduit 26, through first conduit means 32, and into first compartment 22. Fuel entering compartment 22 will fill same, causing additive in compartment 24 to be displaced via second conduit means 36 and into the region of decreased pressure downstream from venturi 28. The additive displaced will be proportioned into the fuel in conduit 26 in proportion to the fuel flow rate in said conduit 26. If desired, the additive displacement rate can be checked visually by means of the graduations shown on the side of container 16. When the fueling operation is completed, valve 40 is closed, and container 16 is uncoupled and discarded.

As a further illustration of the operation of the apparatus of FIGURE 1, it is desired to fuel the integral wing tanks of a small jet aircraft with 200 gallons of jet fuel. Said tanks are coated internally with a Buna N-phenolic resin coating composition and it is thus desirable to use a combination additive in accordance with the invention of said Shotton patent. The specific additive used consists essentially of 99.6 weight percent (99.69 volume percent) of ethylene glycol monomethyl ether and 0.4 weight percent (0.31 volume percent) of glycerol. It is desired that said additive be incorporated in said fuel at an additive level of 0.1 volume percent based on the fuel. The fueling operation is started at a rate of 50 gallons per minute and said additive is blended into the

fuel in the main flow conduit 26 at a uniform rate of about 6.4 ounces per minute during the fueling operation to accurately and uniformly disperse said additive in said fuel. Said rate of 6.4 ounces per minute is obtained by opening valve 40 to a known predetermined setting.

The operation of the apparatus of FIGURE 2 is similar to that described above for FIGURE 1. Assuming that container 16' is empty, compartment 24' thereof is first filled by operation of pump 58 which pumps additive from tank 56 through second three-port valve 52 into said compartment 24'. When this has been completed, said second three-port valve 52 is switched to place compartment 24' into communication with conduit means 36' and first three-port valve 50 is switched to place main flow conduit 26' in communication with first compartment 22'. The apparatus is now ready for fueling operations. Pumping of fuel through conduit 26' to the aircraft or other vehicle being refueled is started and immediately thereafter valve 40' is opened to a predetermined setting, similarly as described above. During the filling operation additive will be displaced from compartment 24' into the fuel flowing through conduit 26' in the manner described above in connection with FIGURE 1.

Upon completion of the fueling operation, valve 40' is closed, three-port valve 52 is switched to place compartment 24' in communication with conduit 54, and three-port valve 50 is switched to place the lower portion of conduit 32' in communication with conduit 62. Pump 58 is then actuated and additive from tank 56 enters second compartment 24' and displaces the fuel from first compartment 22' into container 64. Upon switching of valves 50 and 52 as previously described, the apparatus will now be ready for another fueling operation. If desired, the amount of fuel displaced into container 64 can be checked to furnish a check on the amount of additive blended into the fuel in the previous fueling operation.

From the above description of the invention, it will be apparent to those skilled in the art that the invention provides a convenient and accurate apparatus and method for storing, transporting, and using additives. The devices of the invention are readily capable of supplying additive at the level of 0.1 volume percent based on the fuel with an accuracy of ± 0.02 volume percent or less. At higher additive levels the accuracy is greater. Experience and careful regulation can increase the accuracy at all levels. The entire apparatus of FIGURE 1 can be carried on board the aircraft or other vehicle, if desired. Main flow conduit 26 can be parted at coupling 27 and the portion of said conduit containing venturi 28 carried on board with the remainder of the apparatus. In such instances the other portion of said conduit 26 can be the end of a conventional fueling conduit. Additive containers 16 can be selected in any convenient size, as indicated above, depending upon the size of fuel tanks carried by the vehicle. Preferably, said additive containers 16 are disposable. It is presently preferred to employ plastic bottles or jugs which can be purchased ready filled with the additive. The vehicle operator can carry a supply of said bottles of additive on board and when arriving at a fueling station all that is necessary is to make the connections and refuel as described above. By thus carrying the apparatus and additive supply on board the operator of the vehicle can always be assured that his fuel has been properly treated with additive.

The apparatus of FIGURE 2 can be employed in combination with existing equipment at the majority of (if not all) present fueling stations without requiring extensive modification of said existing equipment. This has obvious advantages in providing an economical solution to the problem of dispensing additives in small quantities.

While the invention has been described with particular reference to being employed in connection with the fueling of aircraft, it is not limited thereto. It will be clear that the invention can be employed in the fueling of land vehicles, such as trucks, tractors, etc., and can also be

employed in replenishing the supply of fuel in stationary fuel tanks, such as employed in building heating installations.

The apparatus and method of the invention can be employed to blend the above additives into all grades of liquid hydrocarbon fuels with which the problems associated with ice formation and/or attack by microorganisms are encountered. Thus, while the invention has been described with particular reference to jet engine fuels, more specifically JP-4 fuel, the invention is not limited thereto. The invention can be used with all other grades of jet fuels such as JP-3, JP-5, and others. The invention can also be used with heavy fuel oils such as Navy Special fuel oil, Bunker C fuel oil, etc. The invention is particularly applicable for use with the distillate fuels boiling in the range from about 100 to about 700° F., such as motor fuel for automotive type engines, other gasolines such as aviation gasoline, naphthas, kerosines, gas oils, diesel fuels for compression ignition engines, burner fuels used in stationary installations for heating purposes, etc.

Also, while the invention has been described with particular reference to blending the above-described additives into liquid hydrocarbon fuels, the invention is not limited thereto. The invention can be employed to blend other additives into other fluids.

While certain embodiments of the invention have been described for illustrative purposes, the invention obviously is not limited thereto. Various other modifications will be apparent to those skilled in the art in view of this disclosure. Such modifications are within the spirit and scope of the invention.

I claim:

1. Apparatus for quantitatively supplying an additive to a fluid stream, said apparatus comprising, in combination: a main flow conduit adapted to be connected at one end to a source of fluid supply; a constriction disposed in said main flow conduit; a portable platform; a container supported on said platform; a handle means extending upwardly from said platform; a band means surrounding said container and connected to said handle means for removably securing said container to said platform; a flexible impermeable diaphragm dividing said container into a first compartment and a second compartment; first conduit means connected at one end to said main flow conduit upstream from said constriction and at the other end to said first compartment of said container; a first dry-break coupler disposed in said first conduit means between said main flow conduit and said container; second conduit means connected at one end to said second compartment of said container, the other end extending into said main flow conduit downstream from said constric-

tion; a flow control means disposed in said second conduit means; and a second dry-break coupler disposed in said second conduit means between said container and said flow control means.

2. An apparatus according to claim 1 wherein said flow control means is a calibrated valve, and said constriction is a venturi.

3. Apparatus for quantitatively supplying an additive to a fluid stream, said apparatus comprising, in combination: a main flow conduit adapted to be connected at one end to a source of fluid supply; a constriction disposed in said main flow conduit; a container; a flexible impermeable diaphragm dividing said container into a first compartment and a second compartment; first conduit means connected at one end to said main flow conduit upstream from said constriction and at the other end to said first compartment of said container; a first three-port valve connected, by means of two of the ports therein, into said first conduit means between said main flow conduit and said container; a drain conduit connected at one end into the third port of said first three-port valve; a graduated container disposed at the other end of said drain conduit; second conduit means connected at one end to said second compartment of said container, the other end extending into said main flow conduit downstream from said constriction; a flow control means disposed in said second conduit means; a second three-port valve connected, by means of two of the ports therein, into said second conduit means between said container and said flow control means; an additive storage tank; a third conduit means connected at one end to said tank, and at the other end into the third port of said second three-port valve; and a pump disposed in said third conduit means adjacent said tank.

4. An apparatus according to claim 3 wherein said constriction is a venturi and said flow control means is a calibrated valve.

5. An apparatus according to claim 3 wherein said constriction is a plate having an orifice therein.

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